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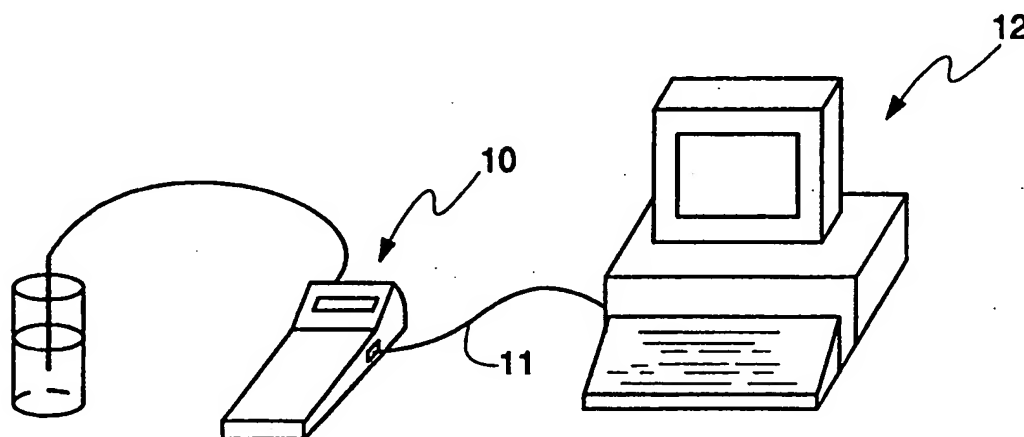
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## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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<b>(21) International Application Number:</b> PCT/US95/08308  <b>(22) International Filing Date:</b> 30 June 1995 (30.06.95)  <b>(30) Priority Data:</b> 269,940                      1 July 1994 (01.07.94)                      US  <b>(60) Parent Application or Grant</b> <b>(63) Related by Continuation</b> US    269,940 (CIP) Filed on                                      1 July 1994 (01.07.94)  <b>(71) Applicant (for all designated States except US):</b> ADA TECHNOLOGIES, INC. [US/US]; Suite 110, 304 Inverness Way South, Englewood, CO 80112 (US).  <b>(72) Inventor; and</b> <b>(75) Inventor/Applicant (for US only):</b> FRENCH, Patrick, D. [US/US]; 3046 South Idalia Street, Aurora, CO 80013 (US).  <b>(74) Agents:</b> SWARTZ, Douglas, W. et al.; Sheridan Ross & McIntosh, Suite 3500, 1700 Lincoln Street, Denver, CO 80203 (US).		<b>(81) Designated States:</b> AM, AT, AU, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IS, JP, KE, KG, KP, KR, KZ, LK, LR, LT, LU, LV, MD, MG, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TT, UA, US, UZ, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG), ARIPO patent (KE, MW, SD, SZ, UG).  <b>Published</b> <i>With international search report.</i>

**(54) Title:** PORTABLE DATA COLLECTION DEVICE**(57) Abstract**

The present invention provides a portable data collection device (10) that has a variety of sensors (52) that are interchangeable with a variety of input ports (16) in the device (10). The various sensors (52) include a data identification feature that provides information to the device (10) regarding the type of physical data produced by each sensor (52) and therefore the type of sensor itself. The data identification feature enables the device (10) to locate the input port (16) where the sensor (52) is connected and self adjust when a sensor (52) is removed or replaced. The device (10) is able to collect physical data, whether or not a function of time.

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## PORTABLE DATA COLLECTION DEVICE

## FIELD OF THE INVENTION

This invention relates generally to portable data  
5 collection devices that may be used in connection with a  
digital computer for computer-assisted education and, more  
specifically, to a portable data collection device that may  
be used by students to collect various types of sensed  
physical data.

10

## BACKGROUND OF THE INVENTION

Digital computers are in widespread use not only among  
post-secondary educational institutions, such as  
universities, colleges, and trade schools, but also among  
15 secondary educational institutions, such as elementary and  
high schools. One major use for computers by educators is  
to assist students in conducting experiments, especially in  
the sciences such as biology, chemistry, earth science, and  
physics. For example, digital computers can be used to  
20 collect physical measurements for later analysis by the  
student.

Existing digital computer systems generally involve a  
personal computer interfaced with one or more sensors to  
collect the physical measurements. Using the digital  
25 computer, the student can later analyze the collected  
physical measurements as a function of a desired variable,  
such as time.

Existing digital computer-based systems for collection  
of physical measurements are poorly suited for use by

-2-

students. Students frequently have limited access to such data collection systems. The significant cost of digital computers often limits the number of computers that an educational institution can purchase for student use. This is especially true for secondary educational institutions which are experiencing increasing budgetary constraints. Consequently, students are frequently limited in the number and length of experiments that they may conduct using the system.

Existing digital computer-based systems are not portable, forcing the student to conduct the desired experiment in the immediate vicinity of the computer. As used herein, the term "portable" shall refer to a device that is hand held and has an internal power source. The spacial limitation on the experiment location limits the variety of experiments that the student may conduct using the computer. For many types of chemical experiments, the spacial limitation increases the risk that during the experiments the computer may be damaged by the chemical compounds used in the experiment, such as acids. The significant cost to repair or replace personal computers magnifies the consequences of this risk.

The software and hardware of existing digital computer-based systems are generally complex to set up and operate, requiring teachers to continuously supervise students during operation of the system. Confusion may arise when the students operate the complex disk operating system and the software interfacing the computer with the

-3-

sensors. Complex command sequences are often required not only to set up the system but also to operate the system during experimentation. Additionally, in some systems the user must inform the computer of the type of sensor located  
5 at a designated port before measurements can be taken. In other systems, a specific type of sensor must be connected to a specific input port. If the sensor is connected to an improper input port, inaccurate measurements may result.

10

## SUMMARY OF THE INVENTION

It is an objective of the present invention to provide an inexpensive portable device for collection of physical measurements.

It is a further objective to provide a portable data  
15 collection device for educational use that can collect a wide variety of physical measurement types.

It is a further objective to provide a portable data collection device for educational use that can be operated by students with minimal teacher supervision.

20

One or more of the preceding objectives is realized by the portable data collection device of the present invention. One aspect of the present invention provides a portable data collection device for collecting various types of sensed physical data. As used herein, "sensed  
25 physical data" shall refer to any type of information that requires the measurement of a quality, characteristic or condition of an object or substance. By way of example, the various types of sensed physical data that can be collected

-4-

by the device include pH, pressure, temperature, velocity, kinetic energy, acceleration, magnetic field strength, electrical field strength, light intensity, period and frequency of rotation, viscosity, sound, humidity, composition, concentration, or other parameters.

The portable data collection device for collecting the sensed physical data includes a portable unit sized for hand-held use and at least one sensor means for providing to the unit a sensed signal representative of the sensed physical data. The portable unit includes; (i) a housing; (ii) processor means mounted within the housing for controlling the input and output of the information from a memory means mounted within the housing for storing the information; (iii) operator control means for controlling the processor means; and (iv) an externally accessible input port extending through the housing that is connected to the processor means. The sensor means includes an interconnection means detachably connected to the externally accessible portion of the input port for providing to the processor means the sensed signal. As used herein, "externally accessible" refers to the ability of the user to remove or replace a sensor means without removing a portion of the housing to access the interior of the device. The interconnection means further includes a data identification means for communicating to the processor means a data identification signal identifying the type of sensed physical data represented by the sensed



-5-

signal. The interconnection means can be permanently connected to the sensor means.

The information stored in the memory means corresponds to the sensed physical data being collected by the sensor means. The information can be any variable or parameter that represents the sensed physical data. Preferably, the information includes at least a numerical value expressing the sensed physical data and a corresponding engineering unit. As discussed below, the value is obtained by applying a preselected scaling factor to the sensed signal. The appropriate scaling factor and engineering unit for a given sensed signal are selected by the processor means based on the data identification signal.

The device can be operated in one of two modes. In a first mode, the device provides the information to a digital computer as received from the sensor means. The device includes connector means for connecting the processor means to the digital computer. In a second mode, the memory means stores the information received from the processor means for later transmission of the information to the digital computer through the connector means. When in either mode, the processor means can access from the memory means instructions to the user as to the operational sequence of the portable device and present the instructions to the user via a presentation means.

In either mode, there are two classes of sensed signals that can be received by the device from the sensor means. The first class of sensed signal is representative

-6-

of sensed physical data that is a function of time and the second class is representative of sensed physical data that is not a function of time. For either class of sensed signal, the sensed signal is an electrical impulse (e.g., voltage, resistance or current). As provided by the sensor means, the first class of sensed signal is generally in digital form and the second class in analog form.

To convert either class of sensed signal to information corresponding to the appropriate type of sensed physical data, the memory means includes a data set indexing the data identification signal against variables associated with the various types of sensed physical data represented by each data identification signal. As noted above, the variables include the scaling factor and an engineering unit corresponding to each scaling factor. For the first class of sensed signal, the scaling factor is preferably applied to the duration of the sensed signal. For the second class, the scaling factor is preferably applied to the magnitude of the sensed signal.

The data identification means enhances the interchangeability of the interconnection means and input ports and simplifies use of the device by communicating to the processor means the location and identity of each sensor means. The data identification signal emitted by each sensor means communicates this data to the processor means without user input. This feature enables the processor means not only to select appropriate variables for each sensor means when the device is turned on but also

-7-

to select appropriate variables substantially simultaneously with the replacement of a sensor means.

The operator control means enables the user to control the processor means. User input includes at least one of the following commands: communicate information to a digital computer, store information in the memory means, and delete information from the memory means. The user can further select a time interval at the end of which the processor means is to receive a sensed signal from the sensor means.

The device can include various additional components depending upon the application. The device can include a plurality of sensor means that are interchangeable with a plurality of externally accessible input ports extending through the housing. Each sensor means includes an interconnection means having a commonly configured output port. The plurality of input ports are commonly configured to attach to the commonly configured output ports. The input ports are preferably in a frictional mating engagement with the interconnection means to enhance interchangeability.

To reduce the dimensions of the device and thereby enhance portability, the plurality of input ports can be oriented in rows and columns on the device. Preferably, at least two of the input ports are offset from one another in a vertical orientation.

The device can include a scaling means for altering the sensed signal to a form corresponding to the variables

-8-

in the data set for converting the sensed signal to information. The scaling means is preferably located within the interconnection means.

The device can include a high resolution analog-to-digital converter means for converting the sensed signal from analog to digital form and/or an analog-to-digital converter means to convert the data identification signal from analog to digital form. The data identification signal, like the second class of sensed signal, is typically communicated by the data identification means in analog form. The high resolution analog-to-digital converter means preferably has an analog-to-digital capability of at least 16 bits.

The device can include a timer for timing the duration of the first class of sensed signal. As noted above, physical data is determined by the device by applying the appropriate scaling factor against the duration of the first class of sensed signal.

The device can include a chronometer to index the sensed signals received by the processor means as a function of the time and date the sensed signal was received from the sensor means.

In another aspect of the present invention, a portable device for collecting various types of sensed physical data is provided that includes a portable unit sized for handheld use and at least one sensor means for providing a sensed signal representative of the sensed physical data. As in the above-noted aspect of the portable data

-9-

collection device, the portable unit includes: (i) a housing; (ii) a processor means mounted with the housing for controlling the input and output of the information corresponding with the sensed physical data to and from a memory means mounted within the housing for storing the information; (iii) operator control means for controlling the processor means; and (iv) an externally accessible input port extending through the housing operably connected to the processor means. The sensor means includes an interconnection means detachably connected to the externally accessible portion of the input port with the interconnection means including a scaling means for converting the sensed signal to a form corresponding to a preselected scaling factor stored in the memory means to convert the sensed signal into information.

In another aspect of the present invention, a portable device for collecting various types of sensed physical data is provided that includes a portable unit sized for hand-held use and a plurality of sensor means for providing sensed signals representative of the sensed physical data. As in the above-noted aspect of the present invention, the portable unit includes: (i) a housing; (ii) a processor means mounted within the housing for controlling the input and output of the information corresponding with the sensed physical data to and from a memory means mounted within the housing for storing the information; (iii) operator control means for controlling the processor means; and (iv) a plurality of input ports operably connected to the

-10-

processor means. Unlike the previous aspect, each of the plurality of sensor means includes an interconnection means detachably connected to an input port and each interconnection means includes a sensor memory means for  
5 storing information associated with the sensed physical data.

The sensor information in each sensor memory means includes a sensor identifier. The sensor identifier denotes the sensor means to which the sensor identifier  
10 corresponds. Each sensor identifier in each sensor means is different. This feature provides the ability to index sensed physical data by the sensor identifier, thereby enabling a user to identify at a later time the specific sensor means providing the sensed physical data. This  
15 feature is advantageous for verifying the accuracy of sensed physical data after collection.

Each sensor memory means can further include calibration information for calibrating the sensed physical data. The calibration information includes variables  
20 corresponding to a calibration equation stored in the memory means. For example, the calibration information includes: (i) variables for a calibration equation stored in the memory means and a calibration equation identifier to designate the appropriate calibration equation to be  
25 used during calibration; (ii) the appropriate units to display the sensed physical data; and (iii) format information specifying the format to be used by a presentation means to display the sensed physical data.

-11-

The storing of the calibration information in the sensor memory means permits new sensor means to be developed and connected to the device without changes to the device, including the software in the device. This is particularly  
5 advantageous in educational applications where numbers of different types of sensed physical data are required to be collected.

The calibration information can be altered and/or selected by a user. This feature permits a user to modify  
10 the calibration information for a precise calibration of the sensed signals, to display the sensed physical data in different units and/or a different format, to take into consideration changes in the performance of the sensor means over time, and to be taught about calibration and  
15 calibration techniques in educational applications.

The device offers several additional advantages over existing data collection systems. The device uses simpler and lower cost components than the personal computer-based systems presently used by educators. The lower cost of the  
20 device enables educators to acquire more data collection devices and thereby increase student access to the devices.

The device is portable unlike the bulkier and heavier personal computers of existing systems. The portability of the device permits it to be used to monitor experiments not  
25 only in the laboratory but also at locations outside of the laboratory. The device, for example, can easily be transported outdoors to perform a variety of sensed physical data measurements.

-12-

Due to the portability of the device, the device can collect a wider variety of sensed physical data types than many existing systems. The device can be used with a number of sensor means capable of collecting a broad range of physical data types.

The device provides enhanced user convenience over existing systems. The device enables the user to replace the various sensor means without providing input to the device regarding the replacement. The device is able to self-adjust to reflect the changes. By contrast, existing systems often require user input when a sensor is removed or replaced.

15

## BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a three dimensional view illustrating an embodiment of the data collection device connected to a digital computer;

Fig. 2 is a three dimensional view of an embodiment of the data collection device during an experiment;

Fig. 3 is a cross-sectional view of an embodiment of the data collection device;

Fig. 4 is a rear view of an embodiment of the data collection device;

Fig. 5 is a top view of an embodiment of the data collection device;

Fig. 6 is an electrical schematic of an embodiment of the data collection device;



-13-

Fig. 7 is a flow chart of the computer program in an embodiment of the data collection device;

Fig. 8 is an electrical schematic of another embodiment of the data collection device; and

5 Fig. 9 is a flow chart of the computer program in the alternate embodiment of the data collection device.

#### DETAILED DESCRIPTION

Referring to Fig. 1, an embodiment of a portable data  
10 collection device 10 according to the present invention is depicted. The device is also discussed in copending U.S. Patent Application Serial No. 08/269,240 for "Portable Data Collection Device" filed July 1, 1994, incorporated herein by this reference in its entirety. In a first mode of the  
15 portable data collection device 10 shown in Fig. 1, the portable data collection device 10 communicates information corresponding to sensed physical data to a digital computer 12 as the portable data collection device 10 measures the sensed physical data from an experiment. The device 10  
20 includes a connection means 11 for operably coupling the device 10 to the digital computer 12. In this mode, the digital computer 12 can complement the operation of the portable data collection device 10 by performing various analytical functions, such as graphically displaying the  
25 information as a function of the time of measurement of the sensed physical data.

Fig. 2 illustrates a second mode of the portable data collection device 10 that is independent of the digital

-14-

computer 12. In the second mode, the portable data collection device 10 stores the information from the experiment in a memory means for later transmission to the digital computer 12. In the second mode, the portable data  
5 collection device 10 can be used to monitor experiments at locations remote from the digital computer 12 and a power source.

The portable data collection device 10 should have a size and weight that is sufficient for the device 10 to be  
10 hand-held and portable by a user, such as a student. Preferably, the device 10 has a length less than about 8 inches, a width less than about 5 inches, and a height no more than about 3 inches. The device 10 preferably weighs less than about 24 ounces.

15 The hand-held size and portability of the portable data collection device 10 makes it useful for the measurement of a wide variety of sensed physical data. The portable data collection device 10 is especially useful for any application that involves sensed physical data  
20 measurement at locations remote from a digital computer, such as the monitoring of indoor and outdoor experiments or of selected parameters of a manufacturing or production process. The preferred application for the portable data collection device 10 is for use by students at the  
25 secondary and post-secondary levels to measure sensed physical data.

Referring to Figs. 1 through 4, for collecting the various types of sensed physical data, the portable data

-15-

collection device 10 uses a number of sensor means 14 that are interchangeable with a number of commonly configured and externally accessible input ports 16 in the device 10. Each sensor means 14 has a commonly configured output port  
5 15 that detachably connects to the input ports 16 in the device 10. To facilitate removal and replacement of the sensor means 14, the input ports 16 preferably extend through the housing of the device 10 and have a portion that is externally accessible by the user.

10 Referring to Figs. 4 and 6, each sensor means 14 can include (i) a sensing element 52 for measuring the sensed physical data; (ii) an interconnection means 53 for providing to the device 10 a sensed signal representative of sensed physical data; (iii) sensor circuitry 54 for  
15 connecting the sensing element 52 with the interconnection means 53; and (iv) a plug housing 62 to house the interconnection means 53. The interconnection means 53 can include a scaling means 56 for altering the sensed signal 50a to correspond to preselected scaling factors in  
20 the device 10, a digital input means 57 to communicate sensed signals 50b to the device 10, a data identification means 58 for communicating to the device 10 a data identification signal 48 representative of the type of sensing element 52 and type of sensed physical data being  
25 measured by the sensing element 52, and a voltage regulator 60 to provide power to the sensing element 52. These components are discussed in detail below.

-16-

The sensor means 14 provides enhanced user convenience by communicating to the device 10 not only the sensed signal 50 corresponding to sensed physical data but also the type of sensed physical data measured by each sensor means 14. In this manner, the device 10 is able to identify the type of sensor means 14 at each input port 16 without user input. The device 10 is further able to automatically identify the removal and/or replacement of sensor means 14 from an input port 16 by the user without user input.

There are generally two configurations of sensor means 14a, 14b employed by the present invention. One type of sensor means 14a measures sensed physical data that is not a function of time and the other type of sensor means 14b measures sensed physical data that is a function of time. By way of example, the first type of sensor means 14a collects physical data such as the following: pH, pressure, temperature, magnetic field strength, electrical field strength, light intensity, viscosity, sound, humidity, composition, concentration, and other parameters that are not time-based. In contrast, the second type of sensor means 14b collects sensed physical data such as the following: velocity, acceleration, period and frequency of rotation, kinetic energy, period, and frequency, and other parameters that are time-based. The key difference between the two types of sensor means 14 is the time dependency of the sensed physical data collected by the sensor means 14.

The sensor means 14a, 14b each produce a sensed signal 50a, b that is representative of the sensed physical

-17-

data being collected by the sensor means 14. To collect different classes of sensed physical data (e.g., a class that is a function of time and a class that is not a function of time) two different types of sensed signals 50a, b are produced by the sensor means 14a, 14b. Sensed signal 50a from sensor means 14a is typically in analog form. Sensed signal 50b is typically in digital form. For either type of sensed signal 50a, b, the sensed signal 50 is generally an electrical impulse, such as voltage, resistance or current. The two classes of sensed physical data are utilized to simplify the conversion by the microprocessor 36 of the sensed signals 50 to information and reduce the portion of the memory means 40 allocated for storage of the variables required to convert the sensed signals 50 to information.

To convert each type of the sensed signals 50a, b to information corresponding to sensed physical data, the device 10 includes a first data set containing variables for converting the sensed signals 50a, b to information with the variables selected for a particular sensed signal 50 being based upon the data identification signal 48. As discussed below, the data identification signal 48 is communicated by the sensor means 14 to the device 10 and is representative of the type of sensed physical data being measured by the sensor means 14. The variables can be a preselected scaling factor for each type of sensed signal 50 and appropriate engineering units for the scaling factor. The scaling factor is preferably selected based

-18-

upon the desired engineering units for expression of the information to the user and the strength of the sensed signal 50. To convert sensed signal 50a to information, the magnitude of the sensed signal 50a is preferably multiplied  
5 against the appropriate scaling factor for the type of sensed physical data represented by the sensed signal 50a. To convert sensed signal 50b to information, the duration of the sensed signal 50b is preferably multiplied against the appropriate scaling factor for the type of sensed  
10 physical data represented by the sensed signal 50b.

The various components of the sensor means 14 will now be discussed in detail. As noted above, either type of sensor means 14 includes a sensing element 52 for providing the sensed signal 50 to the device 10. The sensing element  
15 52 is typically any device capable of measuring the desired type of sensed physical data. Such devices are generally of three types: resistive, ampometric, and voltaic. The circuitry and components of the sensing element 52 depend on the type of sensed physical data to be measured. For  
20 example, the sensing element 52 can be a motion sensor to measure velocity, acceleration, and kinetic energy or a probe to measure the pH of a solution.

The interconnection means 53a, 53b communicates the sensed signal 50 to the device 10 and provides the data  
25 identification signal 48 to the device 10 to identify the type of sensed physical data being measured by the sensing element 52 and therefore the type of sensing element 52 in the sensor means 14. The data identification means 58

-19-

communicates the data identification signal 48 to the processor means 18 to enable the device 10 to identify the sensor means 14 at each input port 16. The data identification signal 48, which is generally in analog form, indicates the type of sensed physical data that is represented by the sensed signal 50 and therefore the type of sensing element 52. The data identification signal 48 enables the device 10 to identify the type of sensing element 52 in and the type of sensed physical data received from each sensor means 14 without input from the user. The data identification signal 48 further enables the device 10 to identify the removal and/or replacement of a sensor means 14 by the user without user input.

The data identification means 58 is composed of one or more resistors in the portable data collection device 10 that are electrically connected in the interconnection means 53 to produce the desired magnitude of the data identification signal 48 for the specific type of sensing element 52 and sensed physical data to be measured by sensor means 14. For example, the data identification signal 48 for a sensor means 14a that measures pH is a first voltage or temperature is a second voltage and for a sensor means 14b that measures velocity is a third voltage or kinetic energy is a fourth voltage. Each of the first, second, third, and fourth voltages are different magnitudes.

The voltage regulator 60 in the interconnection means supplies power to the sensing element 52.

-20-

Depending upon the type of sensor means 14, the interconnection means 53 can include either the scaling means 56 for altering the sensed signals 50a to correspond to the preselected scaling factors in the first data set or  
5 the digital input means 57 to communicate sensed signals 50b to the digital input/output 46 for conversion into information. The scaling means 56 preferably converts the magnitude of the sensed signal 50a to correspond to a preselected scaling factor for converting the sensed  
10 signal 50a into information. The scaling means 56 is suitable electrical circuitry to adjust the magnitude of the sensed signal 50a to a level corresponding to the appropriate preselected scaling factor.

In contrast, the digital input means 57 communicates  
15 sensed signal 50b to the digital input/output 46 for conversion of the sensed signal 50b into information by the device 10. The digital input means 57 is any suitable circuitry for communicating a digital signal to the digital input/output 46. Because sensed signal 50b corresponds to  
20 a time-based measurement, the duration of the sensed signal 50b is typically related to the time period upon which the sensed physical data is based. For example, in a velocity measurement, the duration of the sensed signal 50b is related to the time an object requires to travel a  
25 selected distance.

The plug housing 62 contains the above-described elements of the interconnection means 53. The plug housing 62 has an output port 15 that is configured to frictionally



-21-

mate with the input ports 16. The output port 15 is therefore detachable from the input ports 55. To frictionally mate with the various input ports 16, the output ports 15 are generally commonly configured. The  
5 common configuration facilitates the interchangeability of the various input ports 16 with the various output ports 15 of the sensor means 14.

Sensor circuitry 54a, 54b electrically connects the sensing element 52a, 52b with the interconnection means  
10 53a, 53b. The sensor circuitry 54 is generally an electrical conductor, such as a wire, that is electrically compatible with the sensing element 52 and interconnection means 53.

The various elements of the portable data collection  
15 device 10 will now be described. Referring to Figs. 1 through 6, the portable data collection device 10 includes a housing 34, a processor means 18 for controlling the input and output of information corresponding with the sensed physical data to and from a memory means 40 for  
20 storing the information, an interface assembly 20 to interface the sensor means 14 with the processor means 18, an operator control means 24 for controlling the processor means 18, a serial port 26, the input ports 16, a power outlet 28 and internal power source 30, and a power  
25 regulation circuit 32.

The processor means 18 controls the operation of the device 10 in response to user input through the operator control means 24. The processor means 18 includes the

-22-

memory means 40, a microprocessor 36, a chronometer 38, a backup power source 42, an analog-to-digital converter means 44 and a digital input/output 46.

The memory means 40 stores the information for access  
5 by the microprocessor 36. The memory means 40 also stores the software to control the processor means 18 and the variables for converting sensed signals 50 into information. The memory means 40 has volatile and non-volatile portions and random-access (RAM) and read-only  
10 (ROM) portions. The software and variables are stored in a non-volatile ROM. Information is stored in either volatile or non-volatile portions of RAM, depending on the amount of available memory space. The total memory capacity is at least 32K, with the volatile and non-volatile  
15 portions of the memory means, each being at least 16K and the ROM and RAM each being at least 16K.

The microprocessor 36 in the processor means 18 controls the operation of the portable data collection device 10 in response to user input through the operator  
20 control means 24 and the software in the memory means 40. The software is described below in reference to Fig. 7. The microprocessor 36 includes at least one timer (not shown) for microsecond time measurements. The timer is typically used to measure the duration of sensed signal  
25 50b.

The chronometer 38 enables the microprocessor 36 to index sensed physical data received by the microprocessor 36 as a function of the time and date that the sensed

-23-

signal 50 was received by the microprocessor 36. Whereas the timer measures time in small increments, typically microseconds, the chronometer 38 measures time in larger increments, typically seconds, minutes, hours or days.

5       The backup power source 42 provides power to the non-volatile portion of the memory means 40 for preserving data stored in the memory means 40. The backup power source 42 can be any suitable power source for the non-volatile portion of the memory means 40. Preferably, the backup  
10 power source 42 is one or more batteries.

      The analog-to-digital converter means 44 receives the data identification signal 48 in analog form from each sensor means 14 and communicates the data identification signal 48 to the microprocessor 36. The analog-to-digital  
15 converter means 44 can be any suitable analog-to-digital converter.

      The digital input/output 46 receives the sensed signal 50b in digital form from each of the sensor means 14b. The digital input/output 46 communicates the sensed  
20 signal 50b to the microprocessor 36 for conversion into sensed physical data.

      In addition to the processor means 18, the portable data collection device 10 further includes an interface assembly 20 to communicate the sensed signals 50a from the  
25 sensor means 14a to the processor means 18. The interface assembly 20 includes a multiplexer means 64, a voltage protection means 66, and high resolution analog-to-digital

-24-

converter means 68. The interface assembly 20 is contained on printed circuit boards 70a,b mounted on supports 72a,b.

The multiplexer means 64 communicates, in response to a command received from the processor means 18, the sensed signals 50a received by the multiplexer means 64 from the sensor means 14a to the processor means 18. As discussed below, the processor means 18 communicates a command to the multiplexer means 64 for sensed signals 50a from sensor means 14a at a first selected time interval. In contrast, the sensed signals 50b from the sensor means 14b do not pass through the multiplexer means 64. The sensed signals 50b from the sensor means 14b are directly received by the processor means 18 via the digital input/output 46. The multiplexer means 64 can be any suitable multiplexer.

The channel capacity of the multiplexer means 64 should at least equal the number of the input ports 16 configured to accommodate the sensor means 14a. For example, the multiplexer means 64 should have four dual channels for a portable data collection device 10 having four input ports 16 configured to accommodate the sensor means 14a.

The voltage protection means 66 is connected to the high resolution analog-to-digital converter means 68 and the multiplexer means 64 and adjusts the strength of the sensed signal 50a to fall within a predetermined sensed signal strength range to reduce the likelihood of the sensed signal 50a exceeding the electrical capacity of a component of the device 10. The circuitry of the voltage

-25-

protection means 66 depends upon the predetermined sensed signal strength range. The sensed signal strength range is dependent upon the electrical capacity of the processor means 18 and other electrical components of the portable data collection device 10.

The high resolution analog-to-digital converter means 68 converts the sensed signal 50a received from the voltage protection means 66 from analog to digital form. The high resolution analog-to-digital converter means 68 preferably has a strength of at least about 16 bits. The high resolution analog-to-digital converter means 68 provides for accurate sensed physical data measurements and allows for simple circuitry in the scaling means 56. The high bit strength enables the high resolution analog-to-digital converter means 68 to convert to a digital form even sensed signals 50a that are of a low strength. The high resolution analog-to-digital converter means 68 transmits the sensed signal 50a to the processor means 18.

The input ports 16 extend through the housing 34 to provide the externally accessible portion of the input port 16. The portion of the input port 16 inside the housing 34 connects to the processor means 18 and (if appropriate) the multiplexer means 64. The externally accessible portion of the input port 16 removably connects to the interconnection means 53. Like the output ports 15, the input ports 16 are typically commonly configured to facilitate the interchangeability of the input ports 16 with the various output ports 15.

-26-

The number of input ports 16 depends upon the number of sensor means 14 desired for the portable data collection device 10. Preferably, the portable data collection device 10 has at least 4 input ports 16.

5       The various input ports 16 are located in the housing 34 in the rear portion of the device 10. To facilitate ease of use by students and other types of users, the various input ports 16 are located in the rear portion of the housing 34 so as to be externally accessible by the user  
10       without removing a portion of the housing 34. This feature further protects the various components in the interior of the device 10 from damage caused by users, such as students, accessing the interior of the device 10.

To decrease the width of the device 10, the various  
15       input ports 16 are oriented in rows and columns. As shown in Fig. 4, at least two of the input ports 16 are offset from one another in both a horizontal and a vertical orientation.

The input ports 16 can include circuitry that  
20       interfaces with sensed signals 50 not only from the scaling means 56 but also from the digital input/output 57. All of the input ports 16 should have circuitry to communicate a sensed signal 50a from the scaling means 56 to the multiplexer means 64. At least one input port 16 should  
25       have circuitry to communicate a sensed signal 50b from the digital input means 57 to the digital input/output 46.

The operator control means 24 is operably connected to the processor means 18 to provide input from a user to the

-27-

processor means 18. The operator control means 24 has a plurality of individual keys for input.

The individual keys in the operator control means 24 provide different input to the processor means 18 depending upon whether the processor means 18 is in the data view mode (the default mode) or the menu mode. These two modes and the key commands in each mode are discussed in detail below.

The serial port 26 is operably connected to the processor means 18 for interfacing the portable data collection device 10 with the digital computer 12. The serial port 26 operably couples to the digital computer 12 for communicating sensed physical data to the digital computer 12. In an alternative embodiment, the serial port 26 not only communicates sensed physical data to the digital computer 12 but also receives commands from the digital computer 12 and communicates the commands to the processor means 18.

The housing 34 encloses the above-described components of the portable data collection device 10 to protect the components from damage. The housing 34 generally has three sections that are interconnected: a top portion 34a, a bottom portion 34b, and a removable cover 82. The removable cover 82 exposes the internal power source 30 for replacement.

The device 10 can include various other components. A presentation means 22 can be connected to the processor means 18 for providing information to the user. The

-28-

presentation means 22 visually displays to the user information based on the sensed signals 50. The presentation means 22 is preferably a liquid crystal display.

5       The format of the presentation means 22 is illustrated in Fig. 5. The presentation means 22 visually presents information from each sensor means 14 with information displayed at a location on the presentation means 22 corresponding to the location of the sensor means 14  
10       producing the information. In other words, the information is oriented on the presentation means 22 relative to the location of the input port 16 that the sensor means 14 collecting the information is connected to. For example, the information displayed in the upper right hand corner of  
15       the presentation means 22 corresponds to a sensor means 14 connected to the upper right hand input port 16. If the sensor means 14 is moved to another input port 16, the presentation means 22 will alter the display to reflect the new sensor means 14 location.

20       The information presented on the presentation means 22 is the value measured by the sensor means 14 in scaled engineering units. For example, for a sensor means 14 measuring temperature the presentation means 22 would present the measured temperature in either degrees  
25       Fahrenheit or Celsius, as desired.

      The presentation means 22 further presents two cursor signals to indicate (i) when the portable data collection device 10 is logging (e.g., storing) information in the



-29-

memory and (ii) when the portable data collection device 10 is communicating information to a digital computer 12. In the first case, a cursor signal is visible at the center position on the top line of the presentation means 22. In  
5 the second case, a cursor signal is visible at the center position on the bottom line of the presentation means 22.

The portable data collection device 10 can include a power outlet 28 and internal power source 30. The power outlet 28 plugs into an external power source. The internal  
10 power source 30 is contained within the portable data collection device 10 in compartment 76. The internal power source is typically batteries. The internal power source 30 permits the portable data collection device 10 to be transported to experimental locations remote from an  
15 external power source.

A power regulation circuit 32 can be connected to the power outlet 28 and internal power source 30 to maintain a desired power level to the portable data collection device 10. The power regulation circuit 32 protects the  
20 various electrical components of the portable data collection device 10 against the destructive effects of power level fluctuations. The power regulation circuit 32 maintains the voltage of the electrical power to the portable data collection device 10 at a desired level  
25 notwithstanding power level fluctuations. For example if the power outlet source 28 supplies power from an external power source to the portable data collection device 10, the power level may fluctuate in response to power surges or

-30-

outages. If the internal power source 30 supplies power to the portable data collection device 10, the power level may decline during use as power is drained from the second power source 30.

5       The operation and interaction of the above-described components of the portable data collection device 10 will now be described beginning with the operation of the sensor means 14. Referring to Fig. 6, the data identification means 58 communicates the data identification signal 48 to  
10 the analog-to-digital converter means 44 to inform the processor means 18 of the type of sensing element 52 and sensed physical data being collected by the sensing element 52 at each input port 16. The analog-to-digital converter means 44 converts the data identification signal 48 from  
15 analog to digital form and communicates the data identification signal 48 to the microprocessor 36.

In sensor means 14a, the sensing element 52 communicates a sensed signal 50a representative of the sensed physical data collected by the sensing element 52a  
20 to the scaling means 56. The scaling means 56 alters the magnitude of the sensed signal 50a to a magnitude that corresponds to the particular scaling factor in the first data set for the type of sensed physical data represented by the sensed signal 50a. The scaling means 56 then  
25 communicates the sensed signal 50a to the multiplexer means 64 in the interface assembly 20.

The interface assembly 20 receives and holds the sensed signals 50a from each sensor means 14a. At a

-31-

command from the processor means 18, the multiplexer means 64 communicates the sensed signals 50a to the voltage protection means 66. After appropriate adjustments to the magnitudes of the sensed signals, the voltage protection means 66 communicates the sensed signal 50a to the high resolution analog-to-digital converter means 68, which converts the sensed signal 50a from analog to digital form. The high resolution analog-to-digital converter means 68 then communicates the sensed signal 50a to the processing means 18.

In sensor means 14b, the sensing element 52 produces an electrical impulse based upon the motion of an object. By way of example, the sensing element 52 can include two light beams. When an object breaks the first light beam, a voltage is actuated in the sensor circuitry 54. When the object breaks the second light beam, the voltage in the sensor circuitry 54 is deactivated (e.g., a zero voltage exists in the sensor circuitry 54).

The digital input means 57 communicates the sensed signal 50b in digital form to the digital input/output 46 in the processor means 18. The timer (not shown) measures the duration of the sensed signal 50b which translates into a time period correlating to the sensed physical data. With reference to the example, the sensed signal duration represents the time period required by the object to travel the distance between the two light beams. This data may be used to determine physical data values such as the velocity of the object. As will be appreciated, other configurations

-32-

of sensing element 52 may be used to collect physical data that is a function of time.

Referring to Figs. 6 and 7, the operation of the processor means 18 will be described. Fig. 7 illustrates a flow chart for the program that controls the operation of the processor means 18. The microprocessor 36 loads the program when the device 10 is activated.

After loading the program, the microprocessor 36 in box 90 initializes variables for scaling the sensed signals from each sensor means 14 and loads the first data set from a non-volatile portion of the memory means 40. As noted above, the first data set contains scaling factors and appropriate engineering units indexed by the differing magnitudes of the data identification signals 48 emitted by the various types of sensor means 14.

After executing the commands in box 90, the microprocessor 36 in box 94 compares the magnitude of the data identification signals 48 received from each of the sensor means 14 against the first data set to identify the type of sensor means 14 at each input port 16. The microprocessor 36 selects the appropriate variables for each of the sensor means 14 from the first data set and loads the variables and location of each sensor means 14 into a second data set. To obtain the measured value of the physical data, the appropriate variables are applied to the magnitude or duration of the sensed signal 50 to yield the information.

After completing the operations in box 94, the microprocessor 36 in box 98 initializes the channel specifics

-33-

and determines background voltage in the circuitry of the portable data collection device 10. The background voltage is subtracted from the strengths of the sensed and data identification signals 50, 48 to provide a more accurate  
5 determination of the sensed physical data values.

After completing the operations in box 98, the microprocessor 36 in box 102 initializes the system timing interrupt by selecting a first selected time interval based on second and third selected time intervals. The second  
10 selected time interval is a default variable governing the time interval during which the microprocessor 36 communicates to the presentation means 22 information based upon the sensed signal 50a. Preferably, the second selected time interval ranges from about .75 to about 1.5 seconds.  
15 The third selected time interval is selected by the user and governs the time interval during which the microprocessor 36 communicates information to the memory means 40 for later transmission to the digital computer 12 or to the digital computer 12 as received by the processor means  
20 18. Preferably, the third selected interval ranges from about 2 seconds to several hours. The default value of the third selected time interval is about 2 seconds.

The microprocessor 36 communicates a command for sensed signals 50a to the multiplexer means 64 after the  
25 first selected time interval expires. The first selected time interval will be equivalent to the lesser of the second and third selected time intervals. The second and

-34-

third selected time intervals are generally multiples of one another.

As part of initializing system timing interrupt, the microprocessor 36 initializes the interrupt handler for the operator control means 24. The interrupt handler notifies the microprocessor 36 when a user provides input to the operator control means 24 (e.g., a key is pressed).

After completing the operations in box 102, the microprocessor 36 in box 106 initializes the presentation means 22 by selecting the proper character sets, and other variables of the presentation means 22.

In box 110, the microprocessor 36 is idle until the first time interval expires. At the expiration of the first time interval, the microprocessor 36 either provides information to the presentation means 22 or computes information for storage in the memory means 40 for communication to a digital computer 12. The function to be performed by the microprocessor 36 depends on whether the second or third time interval expired.

In box 114, the microprocessor 36 determines if a key was pressed and, if so, identifies in box 118 the mode. The identities of the keys depend upon whether the menu or data view modes are selected by the user.

In the menu mode, the microprocessor 36 in box 122 prompts the user to communicate or download the information stored in the memory means 40 to the digital computer 12. The user responds to the prompt by either pressing the "Yes" or "No" keys. If "Yes" is pressed, the information

-35-

in the memory means 40 is downloaded to the digital computer 12.

Second, the microprocessor 36 in box 126 prompts the user to clear the RAM portion of the memory means 40. The user responds by either pressing the "Yes" or "No" keys. If "Yes" is pressed, the stored sensed physical data is cleared from the memory means 40.

Finally, the microprocessor 36 in box 130 displays the third selected time interval and the remaining capacity of the memory means 40 based on the third selected time interval. The user may adjust the third selected time interval either upward or downward by pressing the "Up" or "Down" keys. The "OK" key returns the microprocessor to the data view mode.

In the data view mode, which is the default mode, the presentation means 22 presents the information for the user unless the user presses the "Log On/Off" or "Computer Monitor On/Off" keys. As depicted in box 134 if the "Log On/Off" key is pressed, the microprocessor 36 communicates information to the memory means 40. A cursor then appears on the display 22 as described above. The microprocessor 36 stops communicating information to the memory means 40 when the "Log On/Off" key is pressed a second time. As shown in box 138 if the "Computer Monitor On/Off" is pressed, the microprocessor 36 communicates to the digital computer 12 information as it is received by the microprocessor 36 from the sensor means 14. A cursor then appears on the presentation means 22 as described above.

-36-

The microprocessor 36 stops communicating information to the digital computer 12 when the "Computer Monitor On/Off" key is pressed a second time.

5 The user may select either the menu mode while in the data view mode or the data view mode while in the menu mode by depressing the "Menu" and "View" keys, respectively.

10 In box 142, the microprocessor 36 determines if any sensor means 14 was replaced or removed. If a sensor means 14 was replaced at or removed from an input port 16, the microprocessor 36 in box 146 determines the type of sensor means 14 at the input port 16 based upon the data identification signal 48. The microprocessor 36 then loads the appropriate variables for the new sensor means 14 (e.g., scaling factors and engineering units) from the  
15 first data set into the second data set.

In box 150 the microprocessor 36 determines if the first selected time interval has expired. When the first selected time interval expires, the microprocessor 36 in box 154 communicates a command to the multiplexer means 64  
20 for the sensed signals 50a. The command is repeated until the sensed signals 50a are received from each of the sensor means 14a.

In box 158, the microprocessor 36 applies the appropriate variables to each of the sensed signals 50 to  
25 acquire the information.

In box 162, the microprocessor 36 determines based on user input from the operator control means 24 in box 138 whether the information is to be communicated to the



-37-

digital computer 12. The microprocessor 36 in box 166 communicates the information to the digital computer 12, as appropriate.

5 In box 170, the microprocessor 36 determines, based on the third selected time interval and user input from the operator control means 24 in box 122, whether information is to be logged or stored in RAM. In box 174, the microprocessor 36 communicates the information to the memory means 40, as appropriate.

10 In box 178, the microprocessor 36 determines, based on the second selected time interval, whether the information is to be communicated to the presentation means 22. The microprocessor 36 communicates in box 182 the information to the presentation means 22, as appropriate.

15 After determining whether to communicate the information to the presentation means 22 in box 182, the microprocessor 36 returns to box 110 in the flow chart to repeat the steps described above after an interrupt command is received by the microprocessor 36.

20 Referring to Fig. 8, another embodiment of the portable data collection device 10 will be discussed. An important difference between the sensor means 200 of this embodiment compared to the sensor means 14 of the prior embodiment is that, unlike the previous embodiment, the data identification means 204 includes a sensor memory means (not shown). In the prior embodiment, the data  
25 identification means 58 in each sensor means 14 communicated a data identification signal 48 in analog form

-38-

to the processor means 18, which would apply the proper scaling factor(s) stored in the memory means 40 to the sensed signal 50 received from the sensor means 14 to provide sensed physical data. This process is called calibration. In contrast, the present embodiment provides sensor information stored in the sensor memory means in the data identification means 204 to the processor means 18. In this embodiment, the data identification signal 208 is represented by the sensor information and is in digital, not analog, form. The sensor information includes calibration information. The calibration information includes not only a calibration equation identifier for selection of a calibration equation stored in the memory means 40 but also values for the unknown calibration constants in the calibration equation. The appropriate calibration equation provides the scaling factor used to convert the sensed signals 50 into sensed physical data.

The sensor memory means is preferably an EEPROM. The EEPROM is an electrically erasable memory chip which does not lose information when the sensor memory means loses power. Thus, the EEPROM does not require a back-up power source. The EEPROM preferably has a memory capacity of 256 bytes.

The sensor memory means stores a variety of sensor information connected with the operation of the sensor means 200. The sensor information includes not only the calibration information referred to above but also a sensor

-39-

identifier of the specific sensor means 200 (e.g., a type of serial number).

The sensor identifier in the sensor information is different for each and every sensor means 200. The sensor  
5 identifier can, but is not required to, indicate the type of sensed physical data collected by a sensor means 200. The sensor identifier can be logged by the processor means 18 along with the sensed physical data collected by the sensor means 200. This provides the ability to index sensed  
10 physical data by the sensor identifier which enables a user to identify at a later time the specific sensor means 200 providing the sensed physical data. This capability is advantageous for verifying the accuracy of sensed physical data after collection. By way of example, if a sensor  
15 means 200 is or becomes defective, a user can determine what sensed physical data was collected by the sensor means 200, even if a number of different sensor means 200 were employed to collect the sensed physical data.

The sensor memory means also provides calibration  
20 information to the processor means 18 for calibration of the sensed physical data. The calibration information can include: (i) the appropriate units to display the sensed physical data (e.g., "pH", "m/s", "°F", and the like); (ii) format information specifying the format to be used by the  
25 presentation means 22 to display the sensed physical data; (iii) the designation of the appropriate calibration equation to be used by the processor means 18 during calibration (e.g., the calibration equation identifier);

-40-

and (iv) the values of the calibration constants used in the calibration equation. The format is based upon the number of characters available on the presentation means 22 for display of the sensed physical data. For example, because the presentation means 22 has a limited number of characters per line, the decimal point must be correctly located to display as much information as possible (e.g., "7.026 pH", "150.1°F", and "34.1 m/s"). The format information is conveyed to the processor means 18 by means of a number denoting which display format of the several possible display formats in the memory means 40 is to be used for the presentation means 22.

The designation of the appropriate calibration equation and the values of the calibration constants for the calibration equation are stored in the sensor memory means while a set of calibration equations is stored in the memory means 40. The calibration equations correspond to specific curve configurations. There is a finite number of calibration equations or curve configurations required for calibration of all of the sensor means 200. Each type of sensor means 200 will use one of the calibration equations or curve configurations. For example, the information respectively stored in the memory means 40 and the sensor memory means is as follows:

-41-

Information in Sensor Memory Means		Information in Memory Means	
Equation Number	Calibration Constant	Equation Number	Calibration Equation
"1"	$A_1, B_1$	"1"	$Y=A_1X + B_1$
"2"	$A_2, B_2, C_2$	"2"	$Y=A_2X^2 + B_2X + C_2$
"3"	$A_3, B_3, C_3, D_3$	"3"	$Y=A_3X^3 + B_3X^2 + C_3X + D_3$
...		...	
"n"	$A_n, B_n, C_n$	"n"	$Y=A_n e^{(B_n X^{C_n})}$

As will be appreciated, a sensor memory means will typically store only one data set of an equation number and the corresponding calibration constants. The sensor memory means will not typically store the calibration constants for a number of different calibration equations. Only one calibration equation generally applies to a given sensor means 200.

The storing of the calibration equations in the memory means 40 and the appropriate calibration equation number and calibration constants in the sensor memory means permits "new" sensor means 200 to be developed and connected to the device without changes to the device, including the software in the device. This feature renders the device extremely versatile. This is particularly advantageous in educational applications where numbers of different types of sensed physical data are required to be collected.

The calibration information in the sensor memory means can be altered by the user with the altered calibration

-42-

information being stored in the sensor memory means. In one embodiment, the altered calibration information replaces a default set of calibration information in the sensor memory means. In another embodiment, the altered calibration information is stored in the sensor memory means separately from the default calibration information. In this embodiment, the user preferably is unable to alter only the default calibration information. This feature permits a user to modify the calibration information for more precise calibration of the sensed signals, to display the sensed physical data in different units and/or a different format, to take into consideration changes in the performance of the sensor means 200 over time, and to be taught about calibration and calibration techniques in educational applications. The ability for a user to alter the calibration information increases the accuracy of the sensed physical data relative to prior art data logging devices. The feature permits a specific sensor means for collecting a specific type of sensed physical data to be calibrated differently from another sensor means 200 for collecting the same type of sensed physical data. As will be appreciated, there will almost always be slight variations in the performance of different sensor means 200 for collecting the same type of sensed physical data. User calibration permits these variations to be taken into account.

The calibration information in the sensor memory means is accessed by the processor means 18 for retrieval. This

-43-

feature permits the processor means 18 to recognize a sensor means 200 automatically without user input. This is especially useful where the device has a plurality of interchangeable sensor means types.

5       The sensor means 200 typically does not include a microprocessor and/or an analog-to-digital converter. Placing a microprocessor and/or an analog-to-digital converter in each sensor means would significantly increase costs. The use of the processing means 18 in the device to  
10       service all of the sensor means 200 represents a significant cost savings in data logging.

Referring to Fig. 9, the operation of the computer program in the data collection device will be described as it relates to the information in the sensor memory means.

15       The computer program is the same as that in Fig. 7 with the exception of the following differences. In box 90, the microprocessor 36 simply initializes variables and does not load the first data set from the memory means 40. The information in the first data set in the previous  
20       embodiment is substantially the same information as that contained in the sensor information in the sensor memory means. In box 94, the microprocessor 36 loads the sensor information in the sensor memory means into the microprocessor 36 and the appropriate calibration equation  
25       from the memory means 40 into the microprocessor 36. In contrast, the previous embodiment read the sensor means types and loaded the appropriate variables from the first data set into the second data set. The same explanation for

-44-

box 90 also applies to box 146. Fig. 9 further includes box nos. 139 and 140 which are not in Fig. 7. In box 139, the microprocessor 36 prompts the user to re-set the time and date of collection of the sensed physical data. In box 140,  
5 the microprocessor 36 prompts the user to alter the calibration information as described above.

The foregoing description of the present invention has been presented for purposes of illustration and description. Furthermore, the description is not intended  
10 to limit the invention to the form disclosed herein. Consequently, variations and modifications commensurate with the above teachings, and skill and knowledge of the relevant art, are within the scope of the present invention. The embodiments described hereinabove are  
15 further intended to explain the best mode known of practicing the invention and to enable others skilled in the art to utilize the invention, and such other embodiments, and with various modifications required by the particular applications or uses of the present invention.  
20 It is intended that the appended claims be construed to include alternative embodiments to the extent permitted by the prior art.



-45-

What is claimed is:

1. A portable device for collecting various types of sensed physical data, comprising:

a portable unit sized for hand-held use, including:

5 a housing;

processor means mounted within the housing for controlling input and output of information corresponding with the sensed physical data to and from a memory means mounted within the housing for storing information;

10 operator control means for controlling the processor means; and

an externally accessible input port extending through the housing that is connected to the processor means; and

15 at least one sensor means for providing a sensed signal representative of the sensed physical data, wherein the sensor means comprises:

an interconnection means detachably connected to the externally accessible portion of the input port for providing to the processor means the sensed signal, the  
20 interconnection means comprising a data identification means for communicating to the processor means a data identification signal identifying the type of sensed physical data represented by the sensed signal.

25 2. The portable device, as claimed in Claim 1, wherein the operator control means provides at least one of the following commands to the processor means: communicate a portion of the information to a digital computer, store

-46-

a portion of the information in the memory means, and delete a portion of the information from the memory means.

3. The portable device as claimed in Claim 1, wherein: the interconnection means and input port are in a  
5 frictional mating engagement.

4. The portable device, as claimed in Claim 1, further comprising:

a scaling means for altering the sensed signal to a form corresponding to a scaling factor stored in the memory  
10 means for converting the sensed signal into information, wherein the scaling means is contained within the interconnection means.

5. The portable device, as claimed in Claim 1, further comprising:

15 a plurality of sensor means, each sensor means comprising an interconnection means; and

a plurality of externally accessible input ports extending through the housing operably connected to the central processor means; and

20 wherein:

each interconnection means is interchangeable with the externally accessible portion of each of the input ports.

6. The portable device, as claimed in Claim 5, wherein:

25 each interconnection means has a commonly configured output port and the plurality of input ports are commonly configured to attach to the commonly configured output ports.

-47-

7. The portable device, as claimed in Claim 1, wherein the memory means comprises:

a data set indexing the data identification signal against variables corresponding to the various types of sensed physical data represented by each sensed signal.

8. The portable device, as claimed in Claim 1, wherein:

the type of sensed physical data includes the following: pH, pressure, temperature, velocity, kinetic energy, acceleration, magnetic field strength, electrical field strength, light intensity, period and frequency of rotation, viscosity, sound, humidity, composition, or concentration.

9. The portable device, as claimed in Claim 1, further comprising:

a digital computer external to the housing; and connector means for connecting the device to the digital computer wherein in a first mode, the connector means provides information to the digital computer as the information is received by the processor means.

10. The portable device, as claimed in Claim 9, wherein:

in a second mode, the memory means stores information received by the processor means for later transmission to the digital computer.

-48-

11. The portable device, as claimed in Claim 1, further comprising:

an internal power source contained within the housing for providing power to the processor means.

5 12. A portable device for collecting various types of physical data, comprising:

a portable unit sized for hand-held use, including:

a housing;

processor means mounted within said housing for  
10 controlling the input and output of information corresponding with the sensed physical data to and from a memory means mounted within said housing for storing information;

operator control means for controlling said  
15 processor means; and

an externally accessible input port extending through said housing operably connected to said processor means; and

at least one sensor means for providing a sensed  
20 signal representative of the sensed physical data wherein the sensor means comprises:

an interconnection means detachably connected to externally accessible portion of the input port, the interconnection means comprising a scaling means for  
25 converting the sensed signal to a form corresponding to a preselected scaling factor stored in the memory means to convert the sensed signal into sensed physical data.

-49-

13. The portable device, as claimed in Claim 12,  
wherein the interconnection means comprises:

a data identification means for communicating to the  
processor means a data identification signal indicating the  
5 type of sensed physical data represented by the sensed  
signal.

14. The portable device, as claimed in Claim 12,  
wherein the device comprises:

a plurality of input ports extending through the  
10 housing; and

the plurality of input ports are interchangeable with  
the plurality of interconnection means.

15. The portable device, as claimed in Claim 14,  
wherein:

15 the plurality of interconnection means have commonly  
configured output ports; and

the plurality of input ports are commonly configured  
to attach to the commonly configured output ports.

16. The portable device, as claimed in Claim 12,  
20 wherein:

the interconnection means is permanently connected to  
the sensor means.

17. A portable device for collecting various types of  
sensed physical data, comprising:

25 a portable unit sized for hand-held use, including:  
a housing;

processor means mounted within said housing for  
controlling the input and output of information

-50-

corresponding with the sensed physical data to and from a memory means mounted within the housing for storing information;

operator control means for controlling said  
5 processor means;

a plurality of input ports operably connected to the processor means; and

a plurality of sensor means for providing sensed signals representative of the sensed physical data, wherein  
10 each sensor means comprises:

an interconnection means detachably connected to an input port, the interconnection means comprising a sensor memory means for storing sensor information connected with the sensed physical data.

15 18. The portable device, as claimed in Claim 17, wherein each sensor memory means comprises a sensor identifier for identifying the specific sensor means to which the sensor identifier corresponds with each sensor identifier in each sensor means being different.

20 19. The portable device, as claimed in Claim 17, wherein each sensor memory means in each interconnection means comprises calibration information for calibrating the sensed physical data.

25 20. The portable device, as claimed in Claim 17, wherein each sensor memory means comprises information for calibrating the sensed signals generated by the sensor means, the calibration information including at least one of a calibration equation identifier and calibration

-51-

constants corresponding to a calibration equation stored in the memory means.

21. The portable device, as claimed in Claim 17, wherein each sensor memory comprises calibration  
5 information for calibrating the sensed signals collected by the sensor means, with calibration information being selected by a user.

22. The portable device as claimed in Claim 17, wherein each sensor memory means in each sensor means  
10 comprises information concerning the appropriate units for the sensed physical data collected by the sensor means.

23. The portable device, as claimed in Claim 17, wherein each sensor memory means comprises information concerning the display of the sensed physical data on a  
15 means for presenting the sensed physical data.

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1 / 11

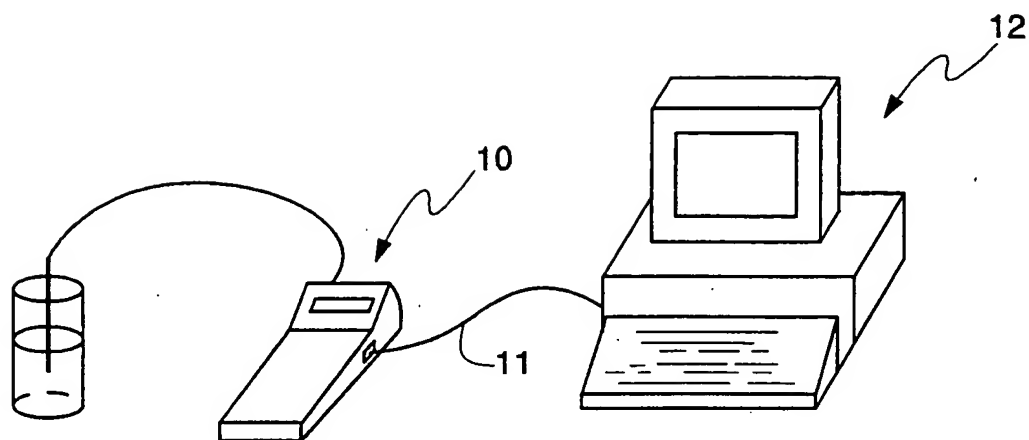


Fig. 1

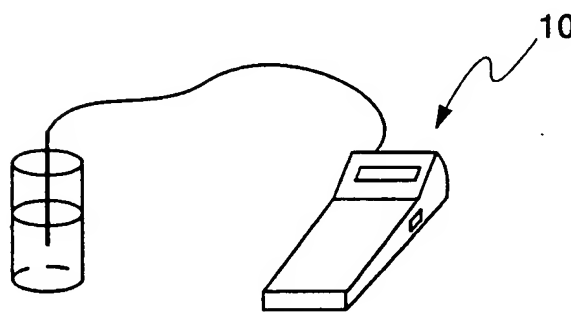


Fig. 2

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2 / 11

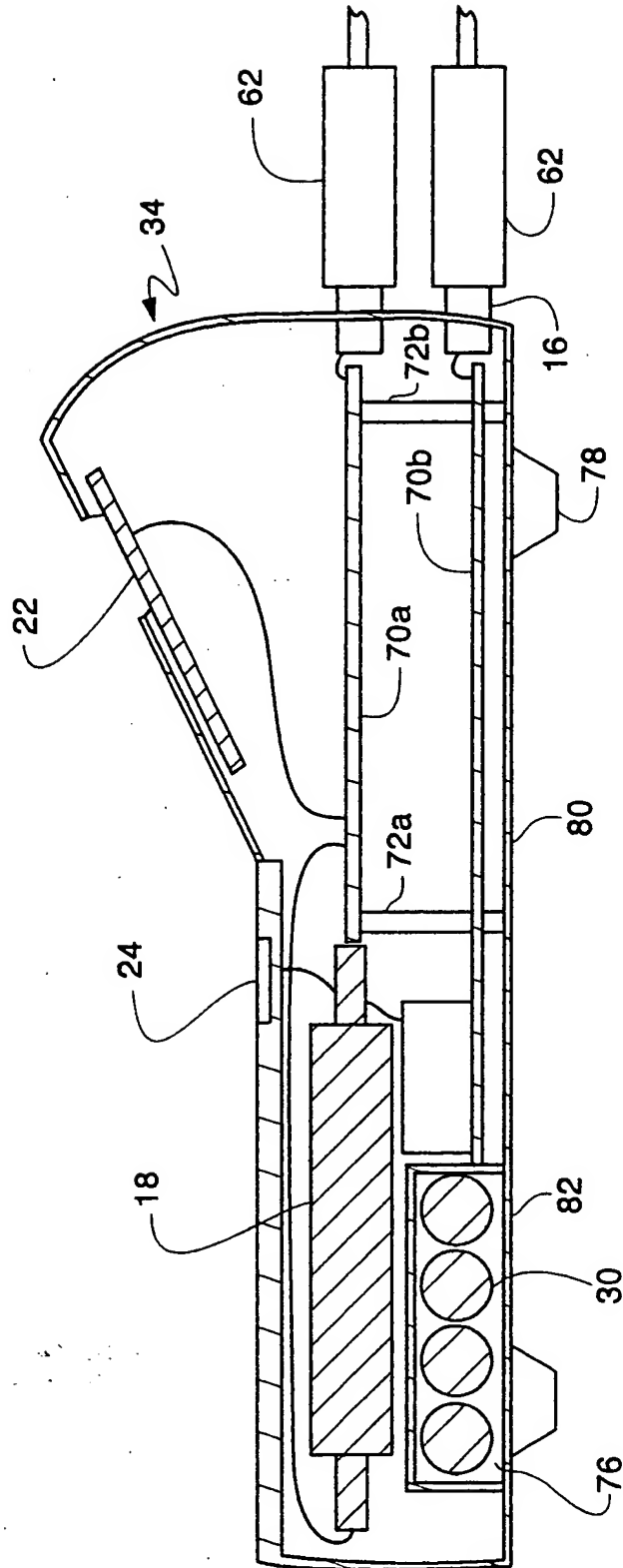


Fig. 3

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3 / 1 1

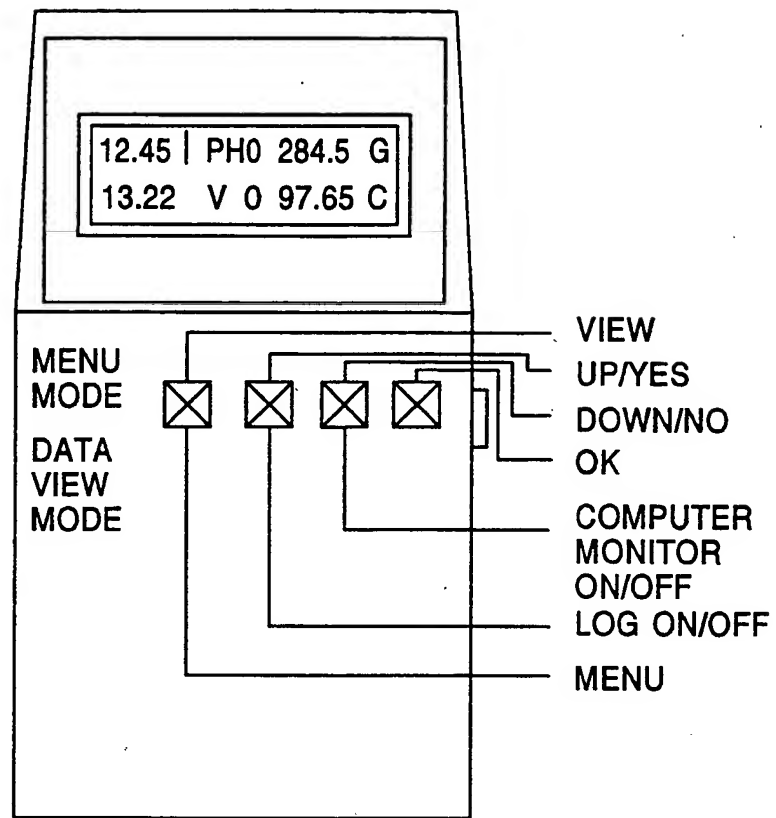


Fig.5

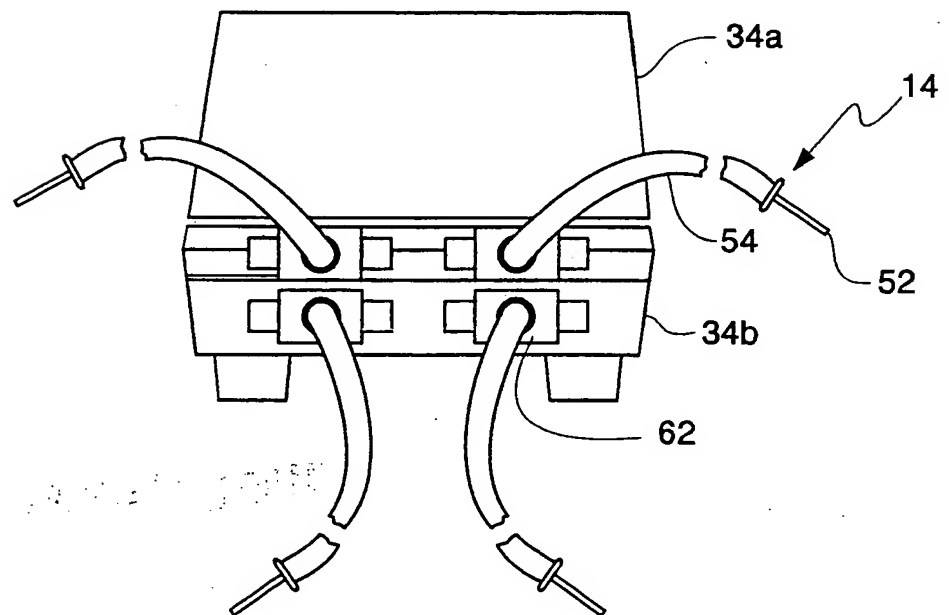
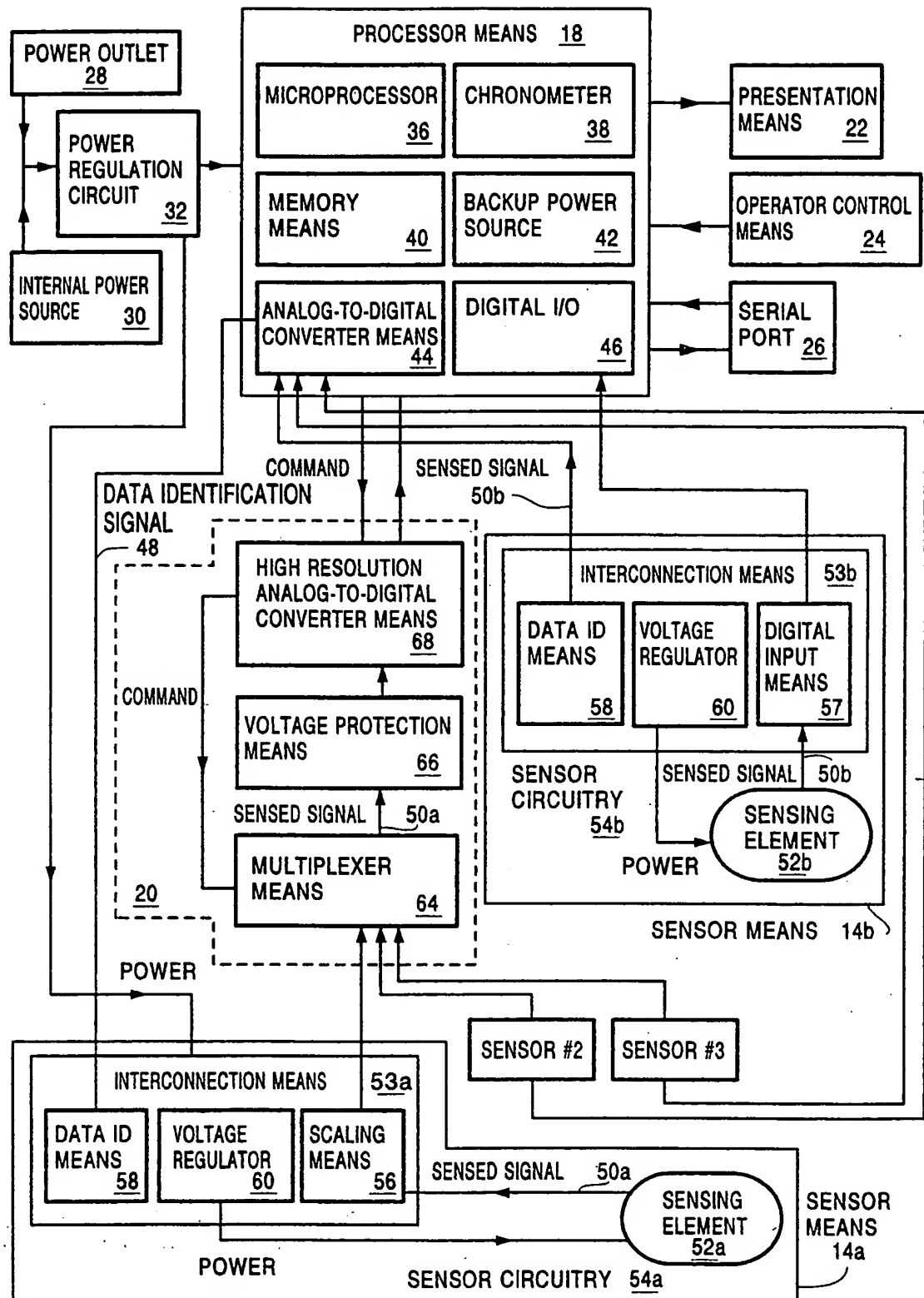


Fig.4

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4 / 11

FIG. 6

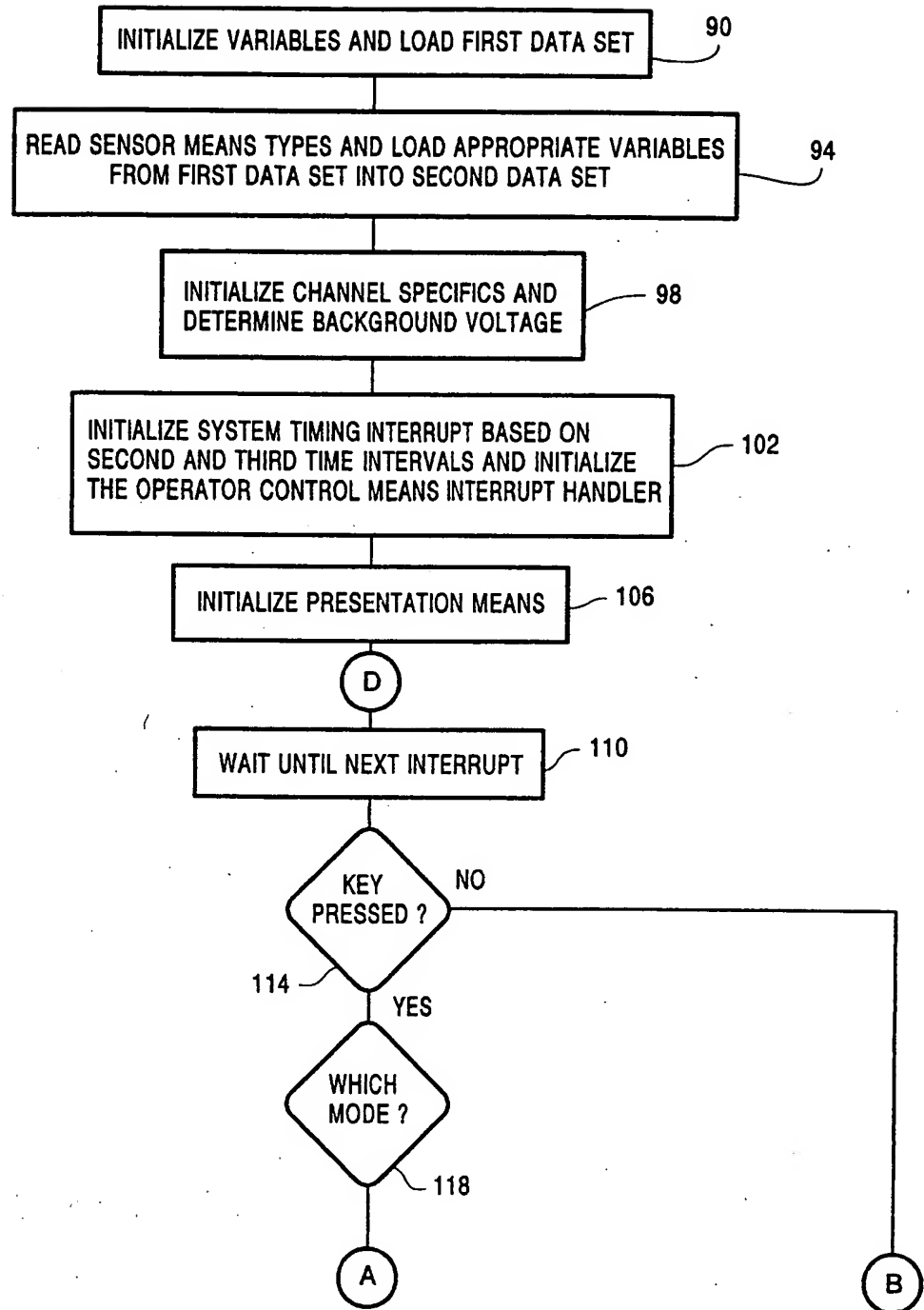


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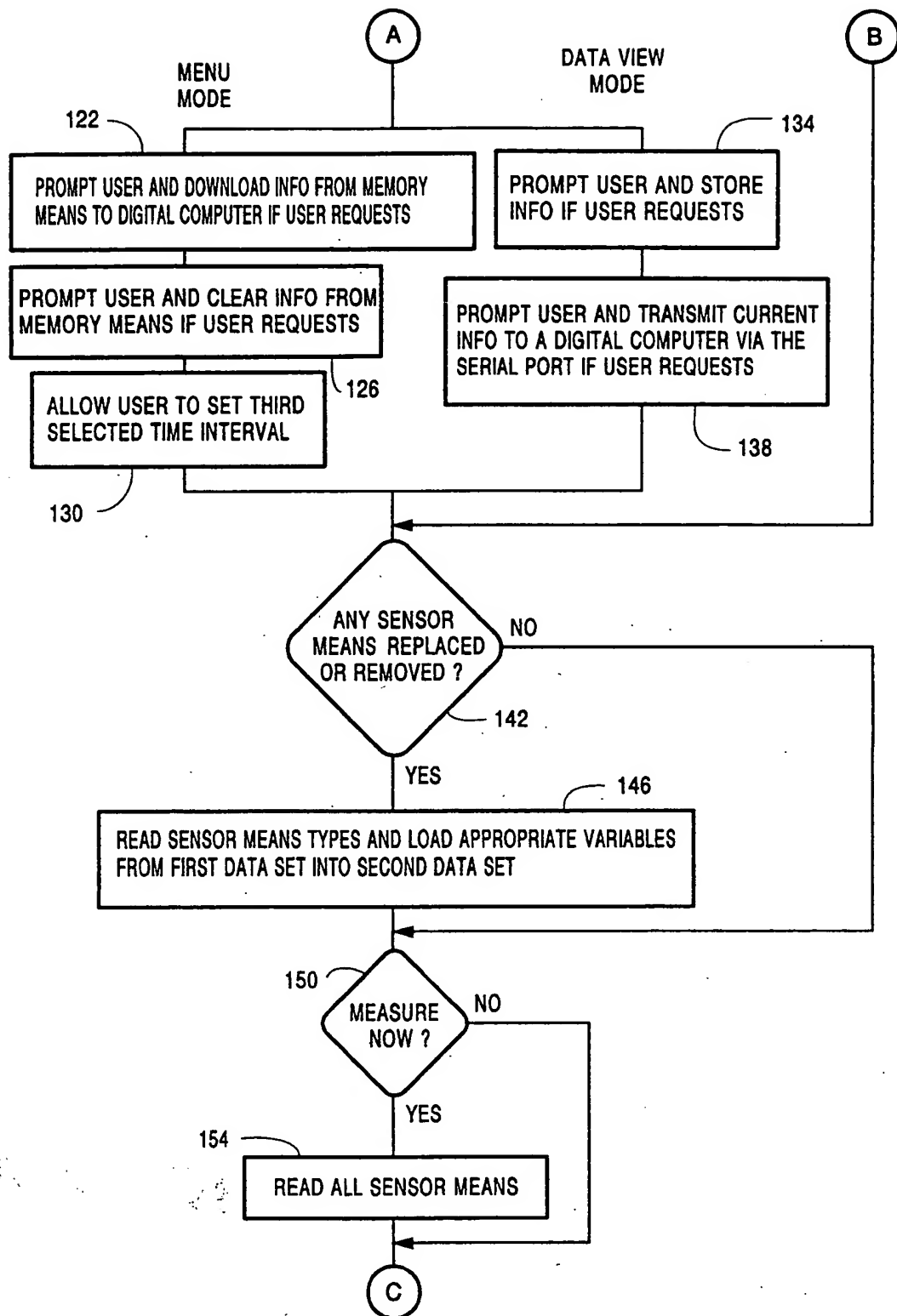
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Fig. 7



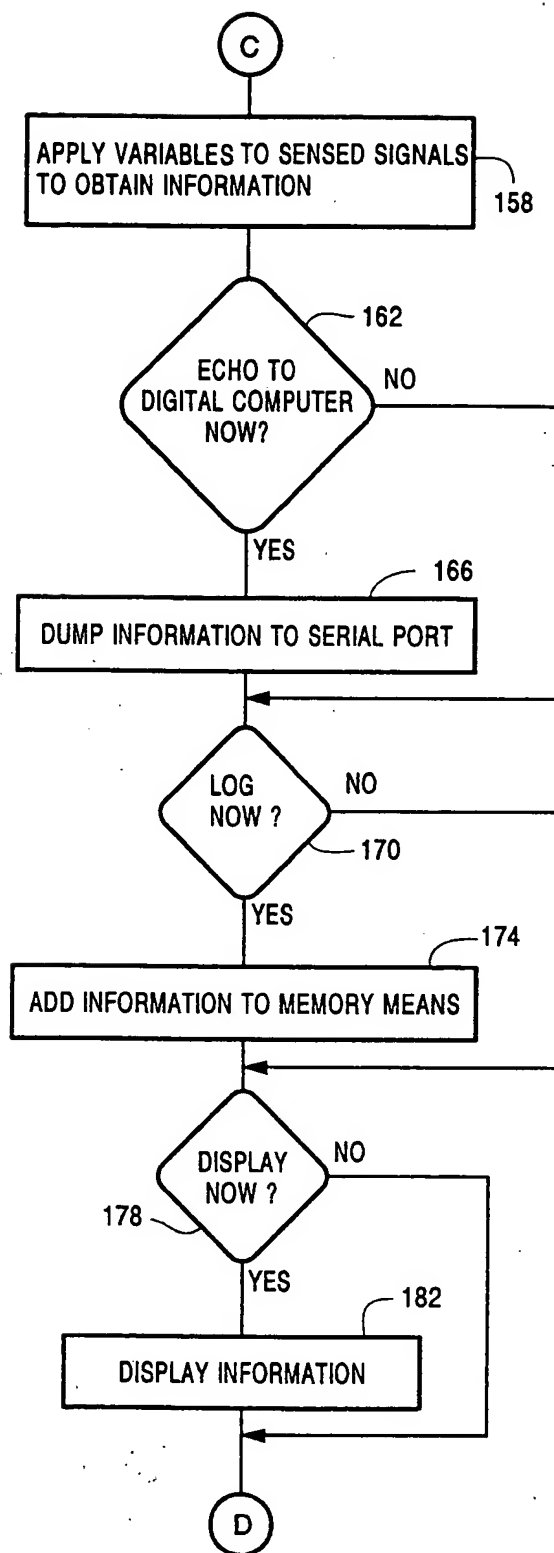
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6 / 11



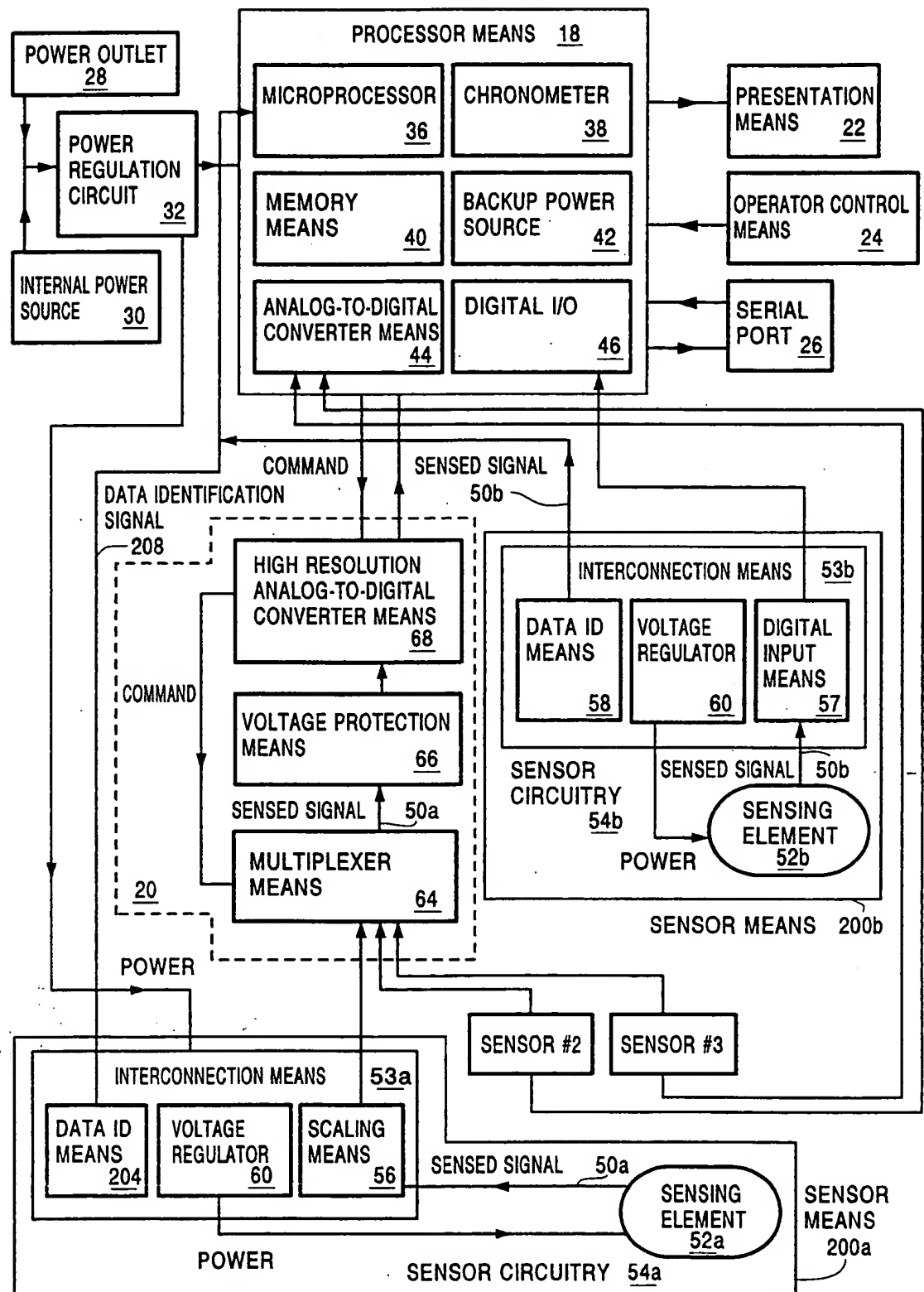
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7 / 1 1



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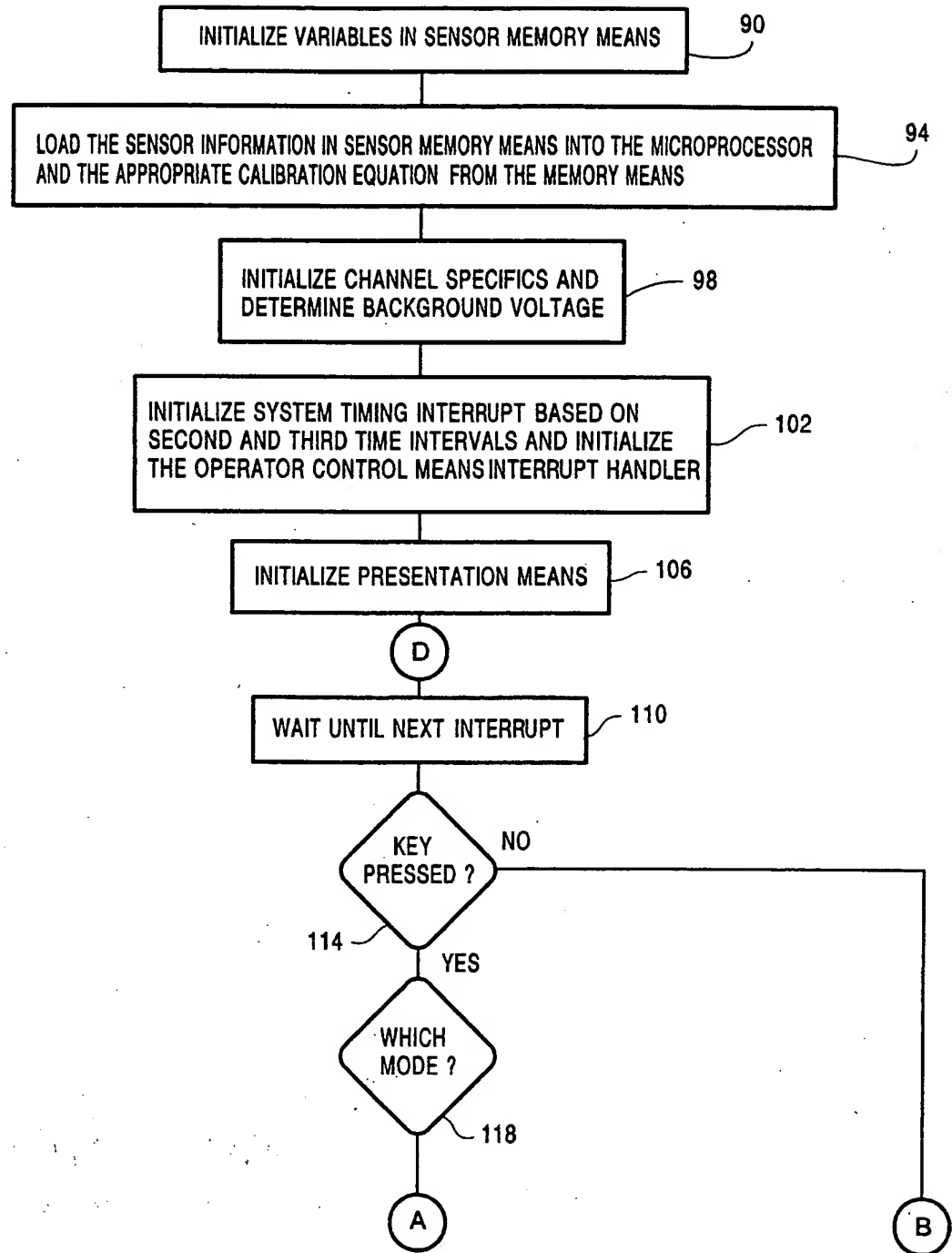
FIG. 8



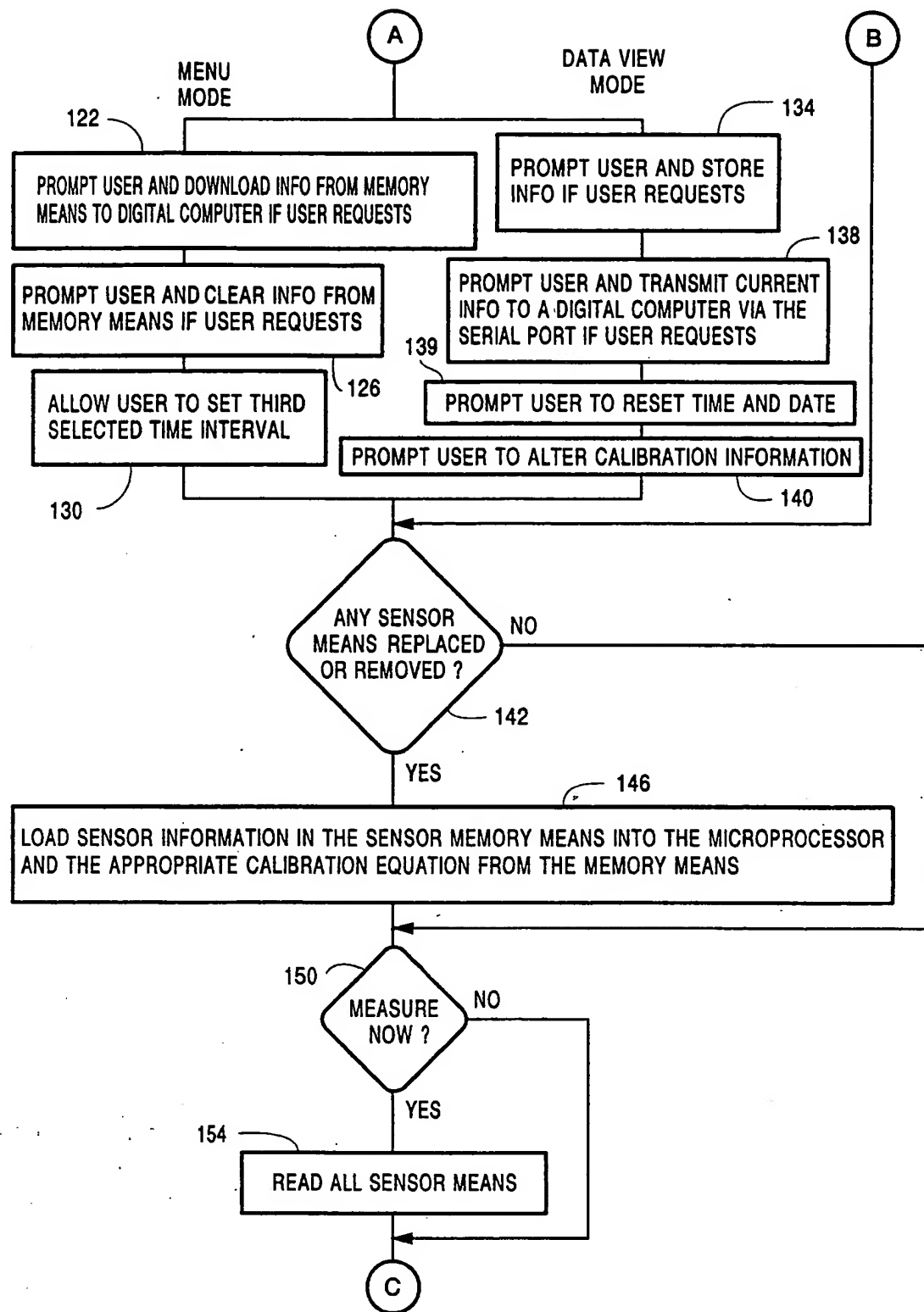
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Fig. 9

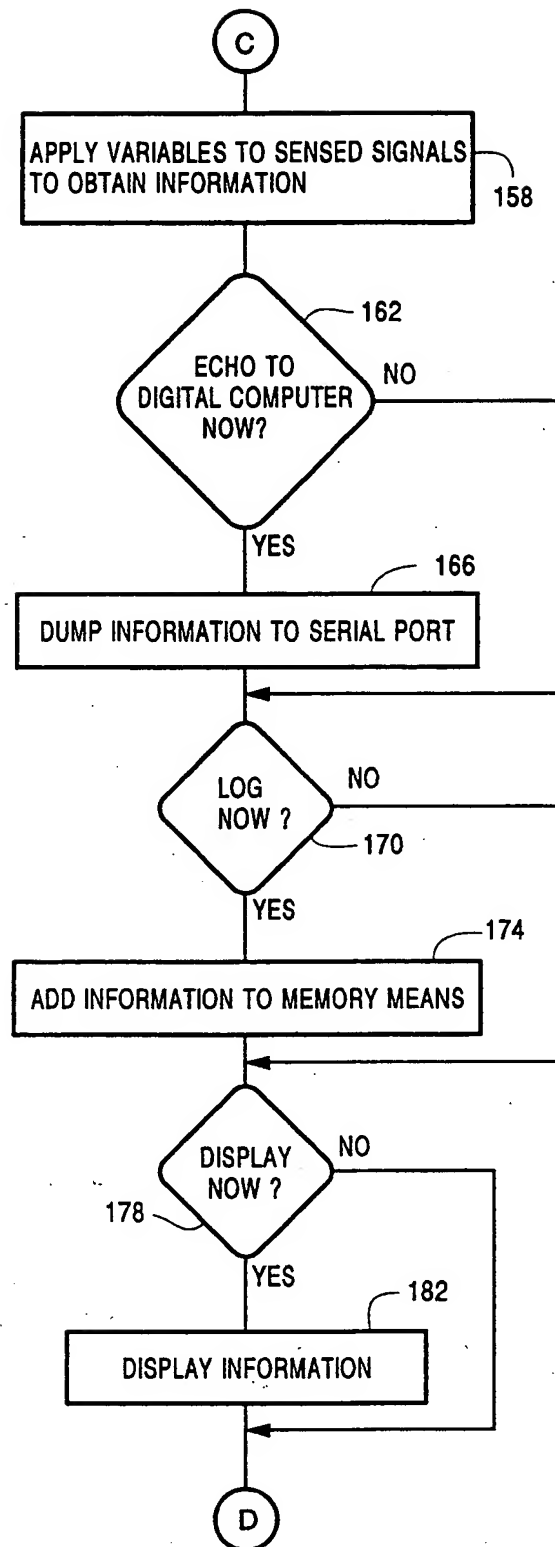


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11 / 11



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## INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US95/08308**A. CLASSIFICATION OF SUBJECT MATTER**

IPC(6) : G01B 21/00

US CL : 364/550

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 364/550, 481, 483; 324/113

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A, 5,227,988 (SASAKI ET AL.) 13 July 1993, Figs. 1-4, claims 1-28 of cols. 8-12.	1-23
Y	Omega Engineering Inc. Sales Literature, Volume 27 Supplement, issued 1991, Omega Engineering, "Data Acquisition Systems", pages F-83 to F-90 and page F-97.	1-23
Y	US, A, 4,758,963 (GORDON ET AL.) 19 July 1988, col. 2, lines 59-66, and col. 5, lines 13-23.	1-23

☐ Further documents are listed in the continuation of Box C.☐ See patent family annex.

* Special categories of cited documents:	*T	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
*A* document defining the general state of the art which is not considered to be part of particular relevance	*X*	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
*E* earlier document published on or after the international filing date	*Y*	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
*L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	*G*	document member of the same patent family
*O* document referring to an oral disclosure, use, exhibition or other means		
*P* document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search

21 SEPTEMBER 1995

Date of mailing of the international search report

03 NOV 1995

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